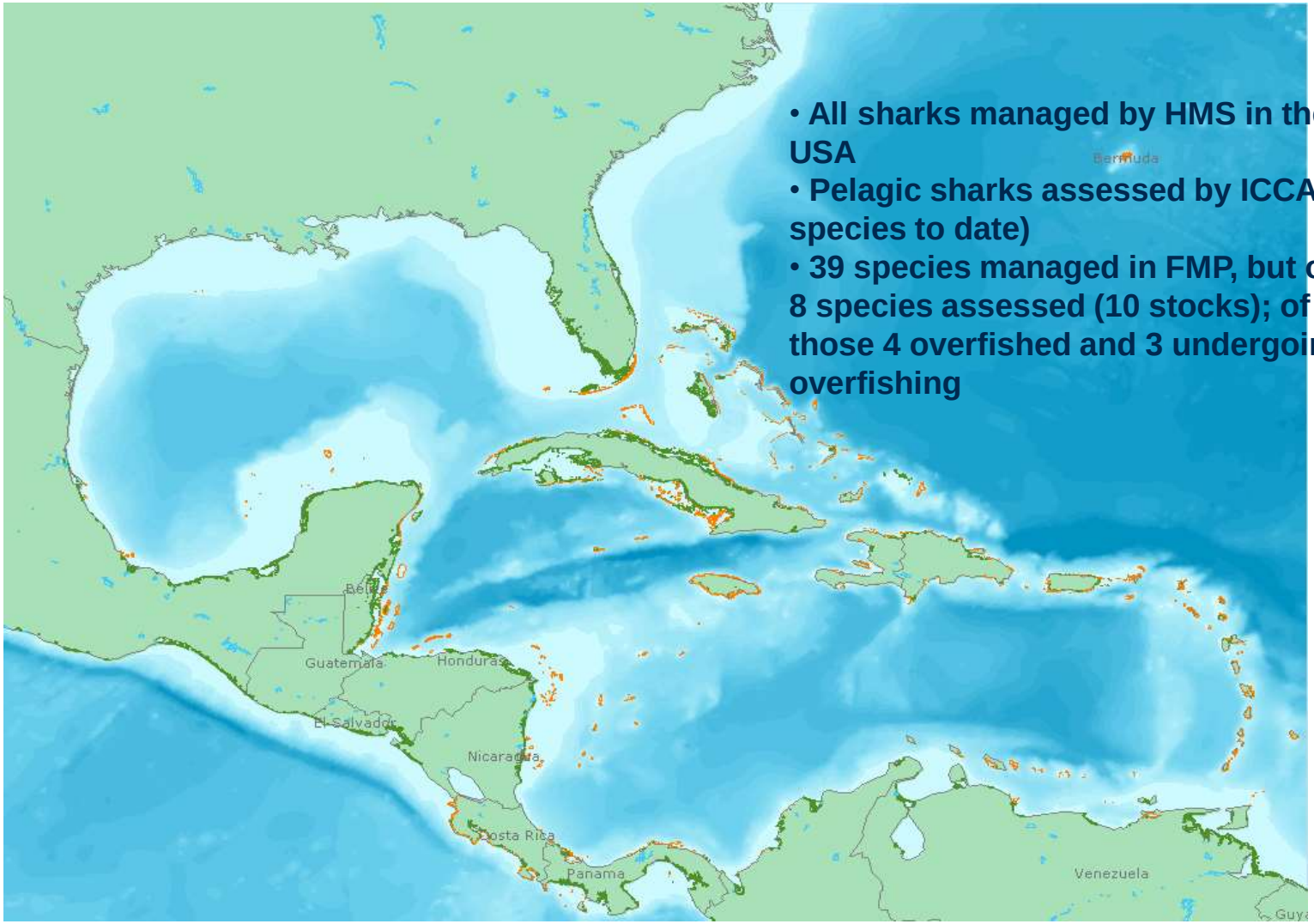
Data Use in Highly Migratory Species (Gulf of Mexico and Atlantic) Shark Stock Assessments

SEFSC PROGRAM REVIEW

June 2013

Management area



- All sharks managed by HMS in the USA
- Pelagic sharks assessed by ICCAT (3 species to date)
- 39 species managed in FMP, but only 8 species assessed (10 stocks); of those 4 overfished and 3 undergoing overfishing

Fisheries

(39 species in FMP; of the 20 non-prohibited species (11 large coastal sharks, 4 small coastal sharks and 5 pelagic sharks) , ~50% have been formally assessed to date)

- Recreational fisheries of similar magnitude to commercial fisheries for most large coastal sharks
- Commercial discards (shrimp trawl fishery main source of removals for 3 of the 4 small coastal sharks)
- Main driver of directed commercial fishery was shark fin market, but it has been greatly reduced in recent years due to quota reductions and other management measures

Data: Generally "Data Poor"

- Fishery Statistics
  - Commercial landings
  - Recreational catches
  - Commercial discards (e.g., shrimp bycatch)
  - Limited size composition
  - No age composition
  - CPUE (standardized indices of abundance)
- Fishery-independent surveys
  - Size composition
  - Relative abundance indices

Stock Assessment Models Used

- There has been an evolution of methods as data became increasingly available
- Model used is dependent on data availability
- Initially only *production models* used
- Followed by increasingly sophisticated production models (consideration of both observation and process error models) and *delay difference models*
- Most stocks assessed more recently with *age-structured production models*
- *Catch-free age-structured production model* used in some cases (e.g., dusky shark)
- Other data-poor methods (e.g., *Ecological Risk Assessments*, *Demographic Analyses, Analytical Reference Points*) also applied but have not been used formally for management by HMS in USA

Evolution of Stock Assessment Models Used

Surplus Production Models

- Catch
- CPUE time series

Delay-difference Models

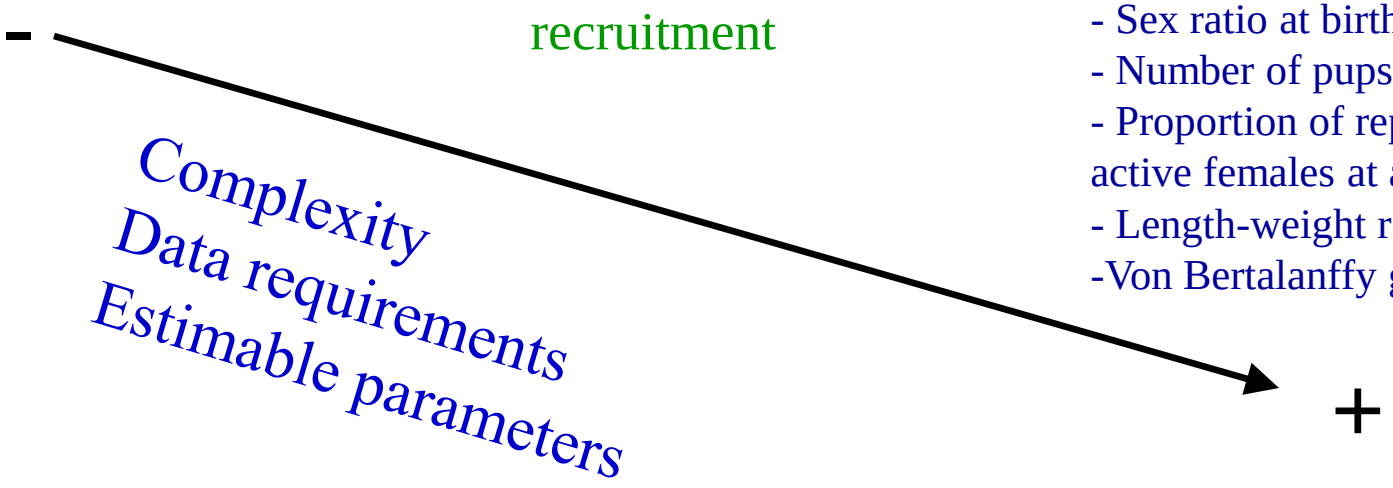
- Catch
- CPUE time series

- Stock-recruitment, survival, and growth
- Lag time between pupping and recruitment

Age-structured Production Models

- Catch by gear type
- CPUE time series
- Gear selectivity parameters
- Biological parameters

- Natural mortality at age
- Maximum age
- Age at maturity
- Sex ratio at birth
- Number of pups at age
- Proportion of reproductively active females at age
- Length-weight relationships
-Von Bertalanffy growth parameters



Shark Stock Assessment Models – Important Data

- Catches (total removals) each year
  - Accurate accounting of all fish landed and discarded dead; also (more recently) those that may die after being released alive
- Indices of Abundance
  - Track changes in stock abundance through time
  - Ideally cover full range of stock and long time period
  - Preferably derived from Fishery-Independent (FI) data to minimize number of factors that may affect indices
- Life History Information
  - Measures of maturity rates and reproductive output
  - Growth curves, length and weight at age, length-weight conversions, etc.
  - Natural mortality rates (estimated through life-history invariant methods)

Shark Stock Assessment Models – Important Data

- Length Samples
  - From commercial (usually limited) or recreational (very limited) fisheries
  - Best length information comes from observer programs (typically, bottom-longline shark observer program)
  - Length samples also available for the different F-I indices (best) and F-D indices

Available Fishery-Dependent Statistics

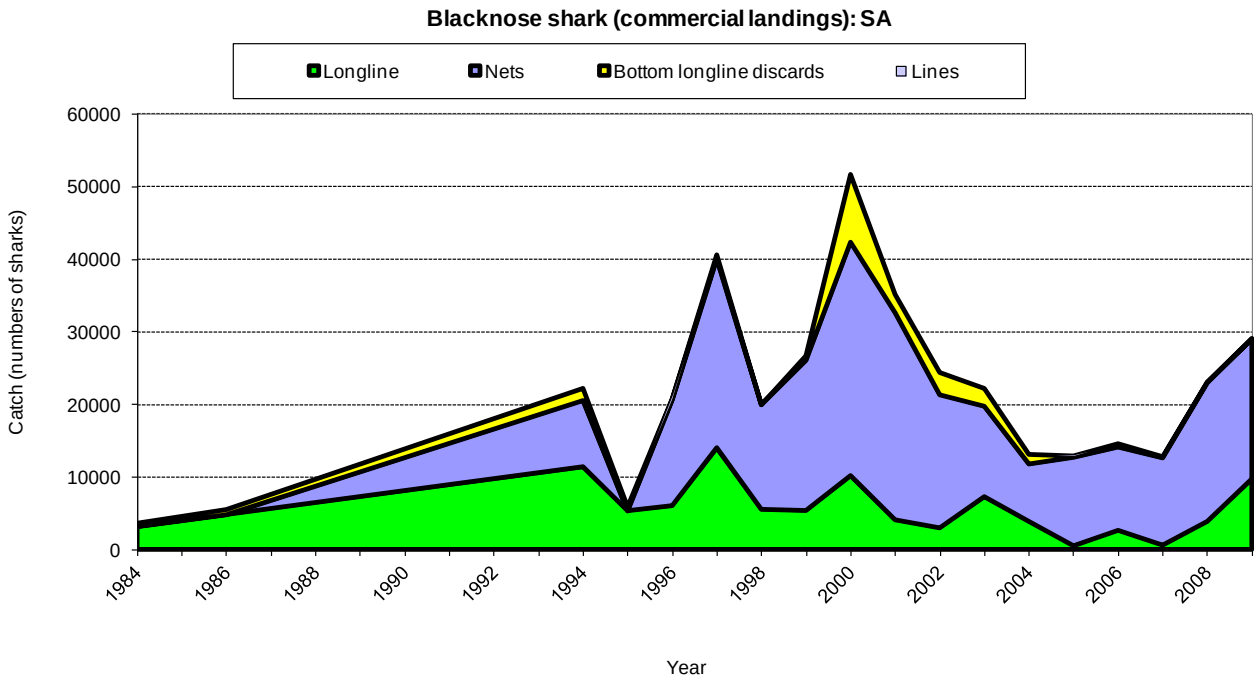
- Landings
- Dead discards
- Length compositions
- CPUE (standardized indices of abundance)

Commercial Landings (typically early 1990s-present)

- Almost census-like
- But very sketchy prior to early 1990s
- Often requires reconstruction to year when stock is assumed to be in “virgin” conditions based on “expert” judgment
- Geographically, state of landing is available; location of capture available from coastal fishery logbook data; but stock assessment models are not geographically explicit

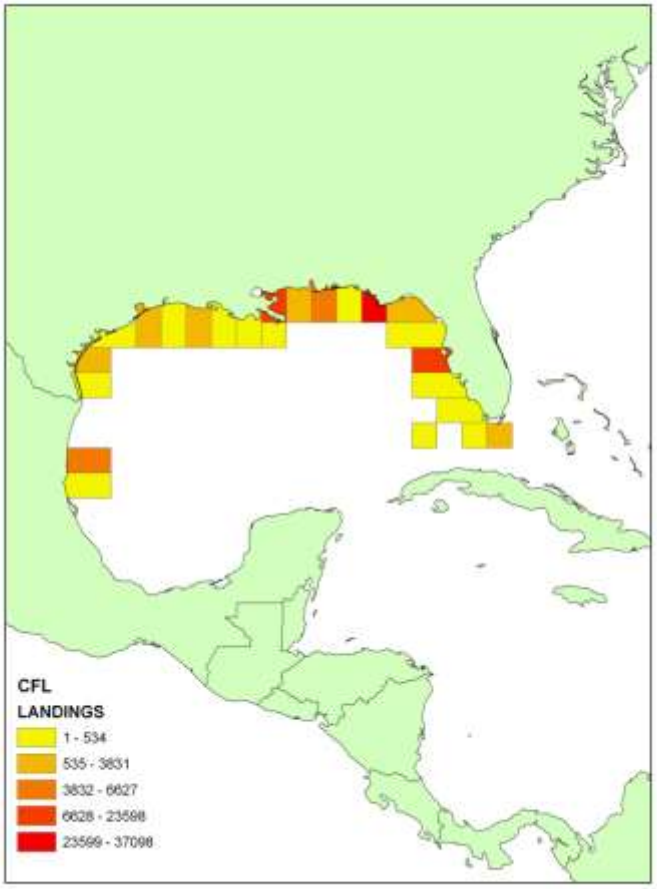
Commercial Landings by gear (typically early 1990s-present)

Example: commercial gear composition for blacknose shark stock in SA



Commercial Landings area of capture

Example: area of capture for blacktip shark stock in GOM (from Costal Fishery Logbook)

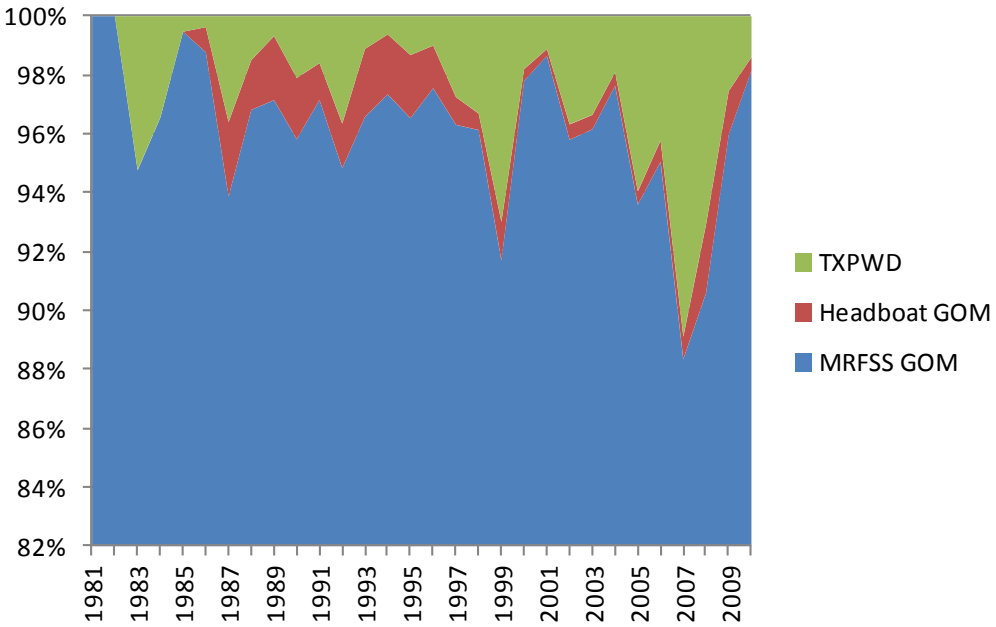


Recreational Landings (1981-present)

- Are estimates
- From three surveys: MRFSS (now MRIP), Headboat, and TXPWD; MRFSS typically accounts for majority of catches
- Use A+B1 (animals landed and discarded dead or used for bait); more recently also account for B2s (animals released alive) that may die (based on very limited post-release survival estimates for a few species)
- Same caveats as reported for other species of fish (imprecision/bias)
- Mis-identification issues likely important for some species of sharks
- As for commercial catches, sometimes also requires reconstruction to year when stock is assumed to be in “virgin” conditions based on “expert” judgment
- Geographically, state of landing is available; location fished is self-reported

Recreational Landings (1981-present)

Example: Catches (A+B1) of blacktip shark in the GOM (from the three surveys)

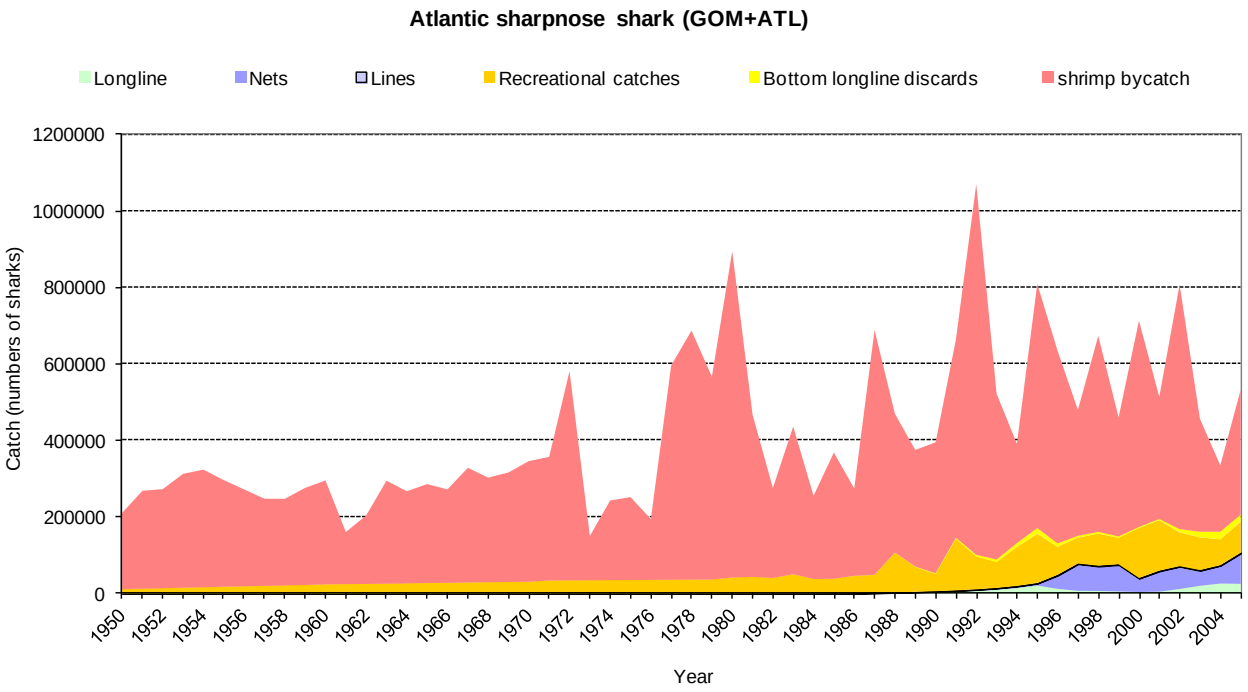


Commercial discards

- Are estimates
- Quality of information available to generate estimates is variable, but generally low:
- Very limited observations with expansion factors to generate total estimates (e.g., menhaden fishery discards or Mexican catches of “US” blacktip sharks in the GOM)
- Often involves some crude assumptions (expert opinion)
- Even when formally estimated, based on few observations:
- Shrimp fishery discards (e.g., GOM blacknose, Atlantic sharpnose, and bonnethead sharks)
- Bottom longline discards (based on logbooks and observer data; use self-reported effort to expand to total numbers)
- Magnitude of dead discards can range from insignificant to one driving the catches

Commercial discards

Example: Catch streams for Atlantic sharpnose shark

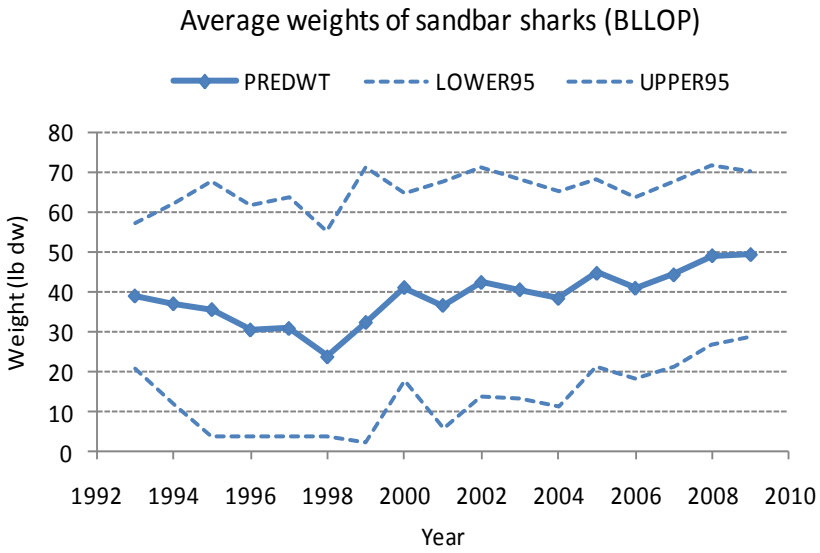


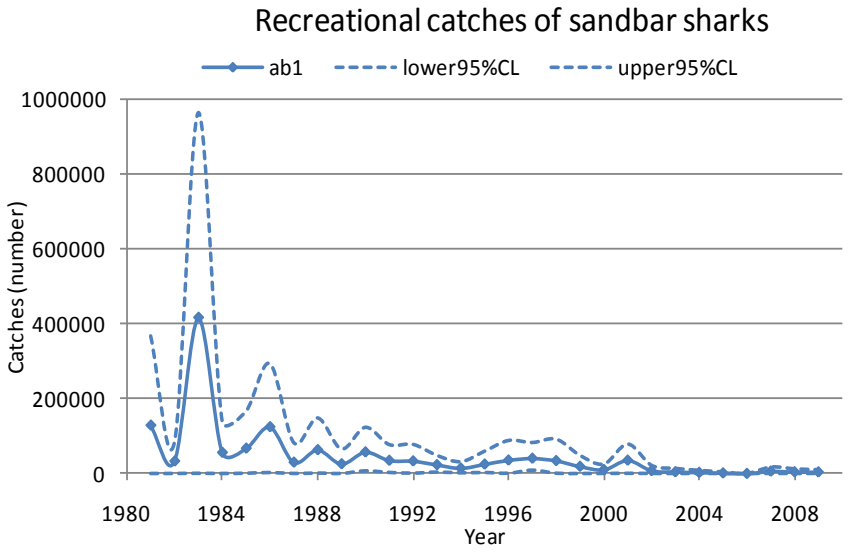
Incorporation of uncertainty in catches

- Assessments tend to give more weight to the catch series ("fit" better than indices)
- Low and high catch scenarios are constructed to account for uncertainty in the data streams:
  - Commercial landings are in weight but are transformed into numbers through average weights obtained from lengths recorded in the observer program(s): 95% CIs of those predicted weights are used to generate low and high landings in numbers
  - Recreational catches (A+B1, in numbers): 95% CIs of those estimates are also used to generate low and high catches in numbers
  - Shrimp discard estimates incorporate CIs
  - Other ad-hoc methods are used to generate low and high scenarios for other data streams (e.g., menhaden fishery discards, Mexican catches)

Low and high catches

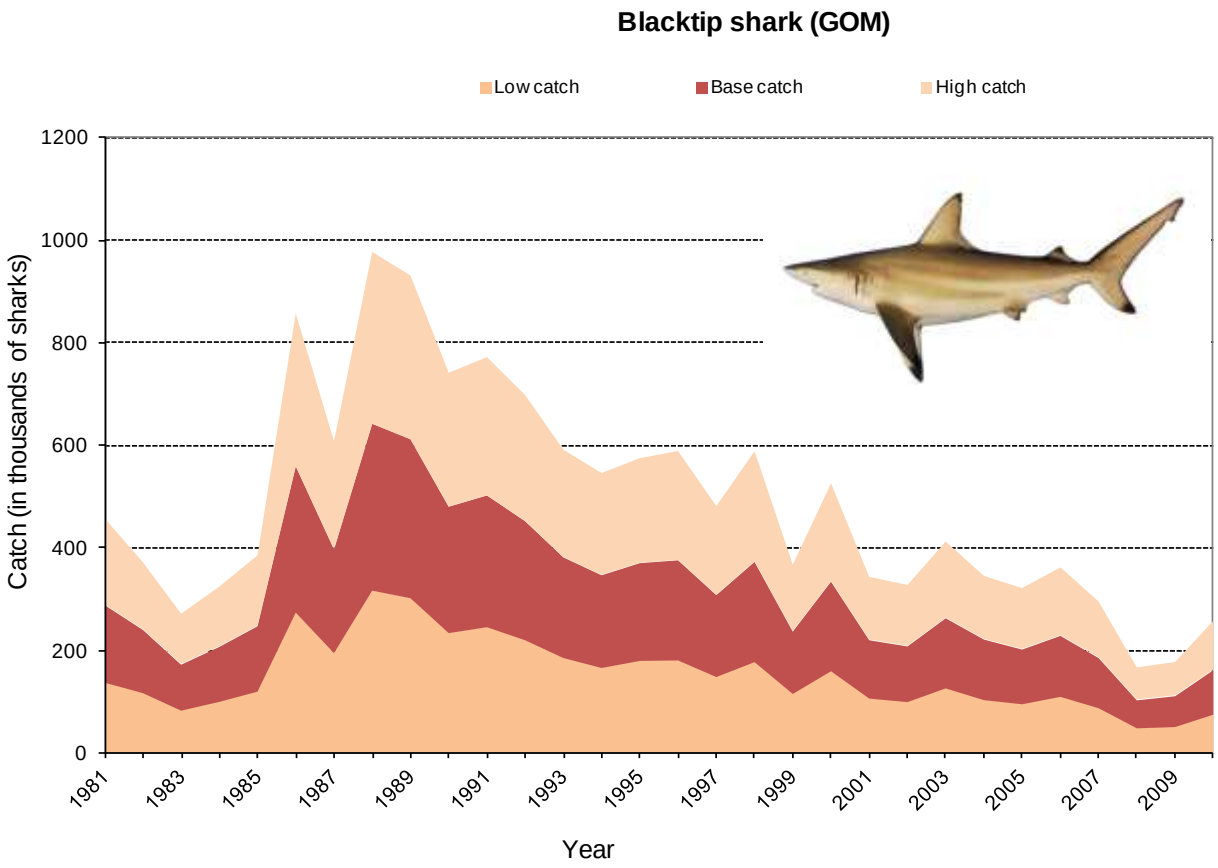
Examples: 95% CIs of average weights for sandbar sharks from Bottom-Longline Observer Program (left); 95% CIs of A+B1 catches of sandbar sharks from MRFSS (right)





Low and high catches

Example: Low, base, and high catch scenarios for GOM blacktip sharks

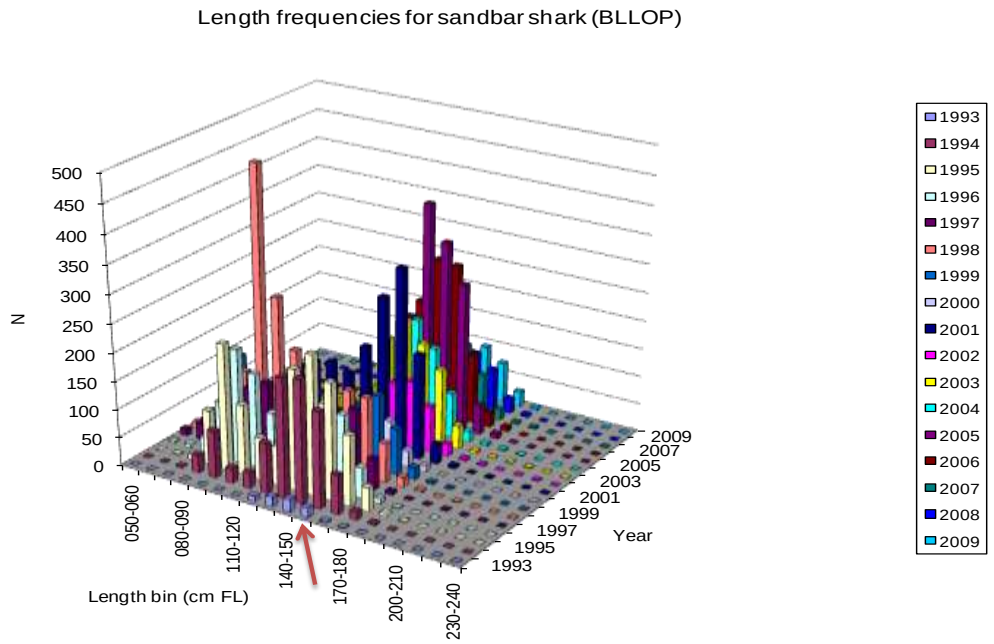


Size Composition of Landings and Discards

- Very few samples from commercial fisheries:
  - Measurements (length) come from observer programs (Bottom Longline, Pelagic Longline, and (Drift) Gillnet observer programs)
- Sample size from recreational surveys generally low
- Sample size from shrimp fishery observer program very low too
- *No routine age samples available*
- Selectivities are fitted externally to the model:
  - First, length samples are combined with original age and growth studies to develop age-length keys
  - The age-length keys are then used to obtain age compositions based on length compositions
  - Selectivity curves are then fitted to the age compositions externally to the model and later imputed into the model

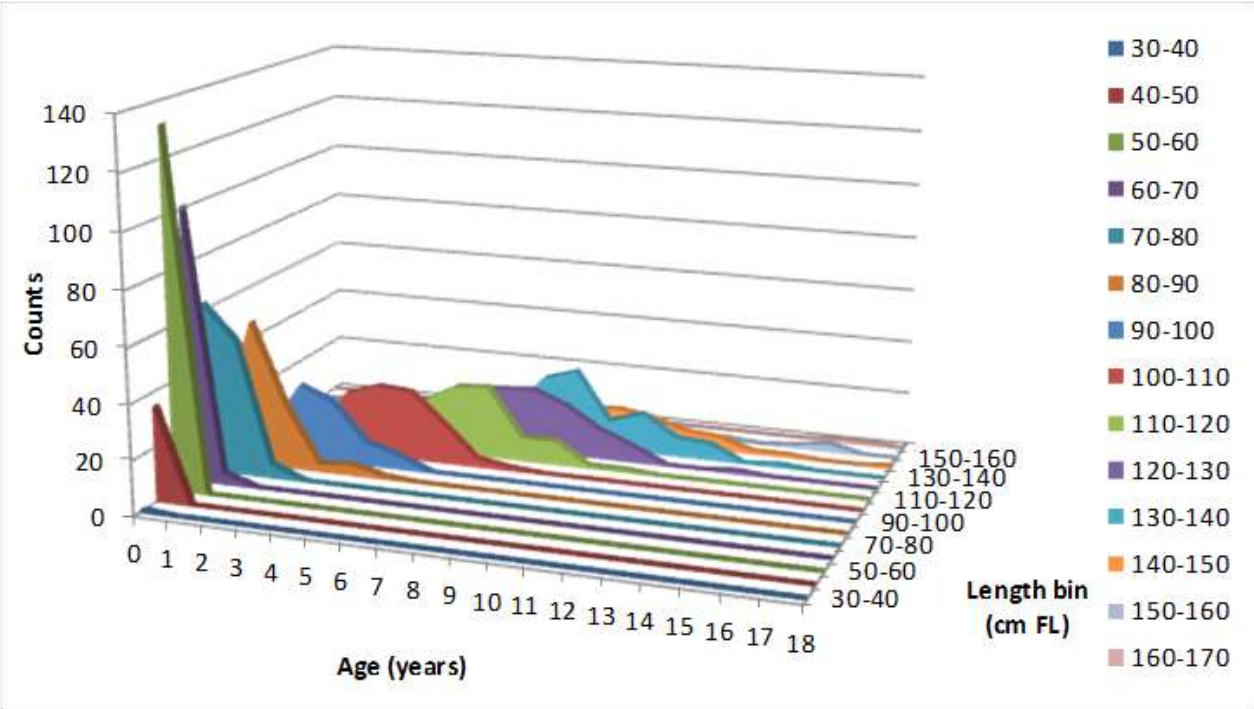
Length Composition of Landings and Discards

Example: Length compositions of sandbar sharks from the Bottom-Longline Observer Program



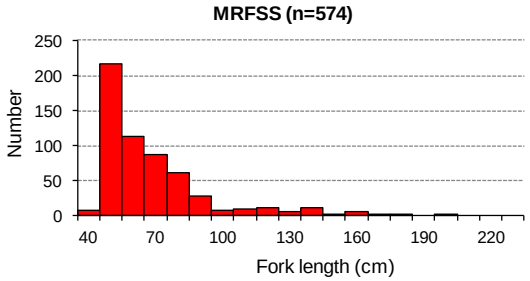
Age-length key

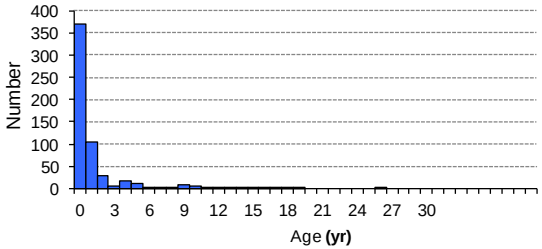
Example: Age-length key for GOM blacktip sharks

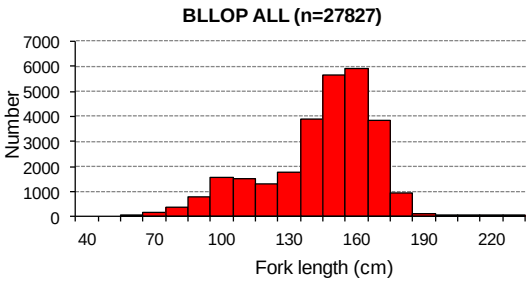


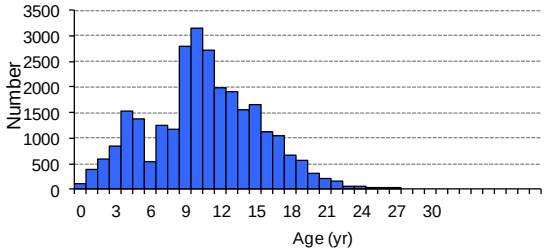
Length and age compositions

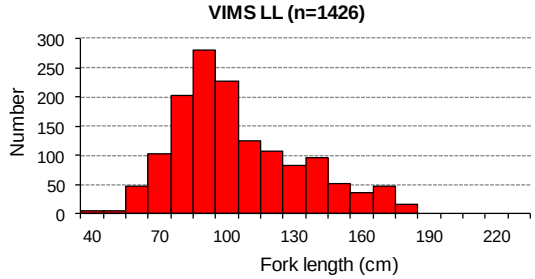
Example: Some length and age compositions for sandbar sharks

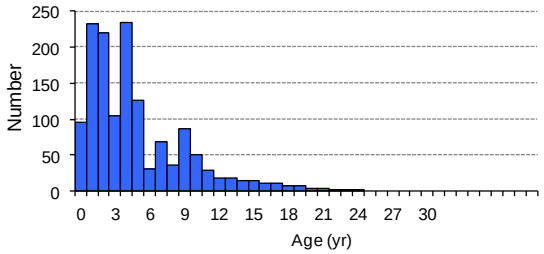






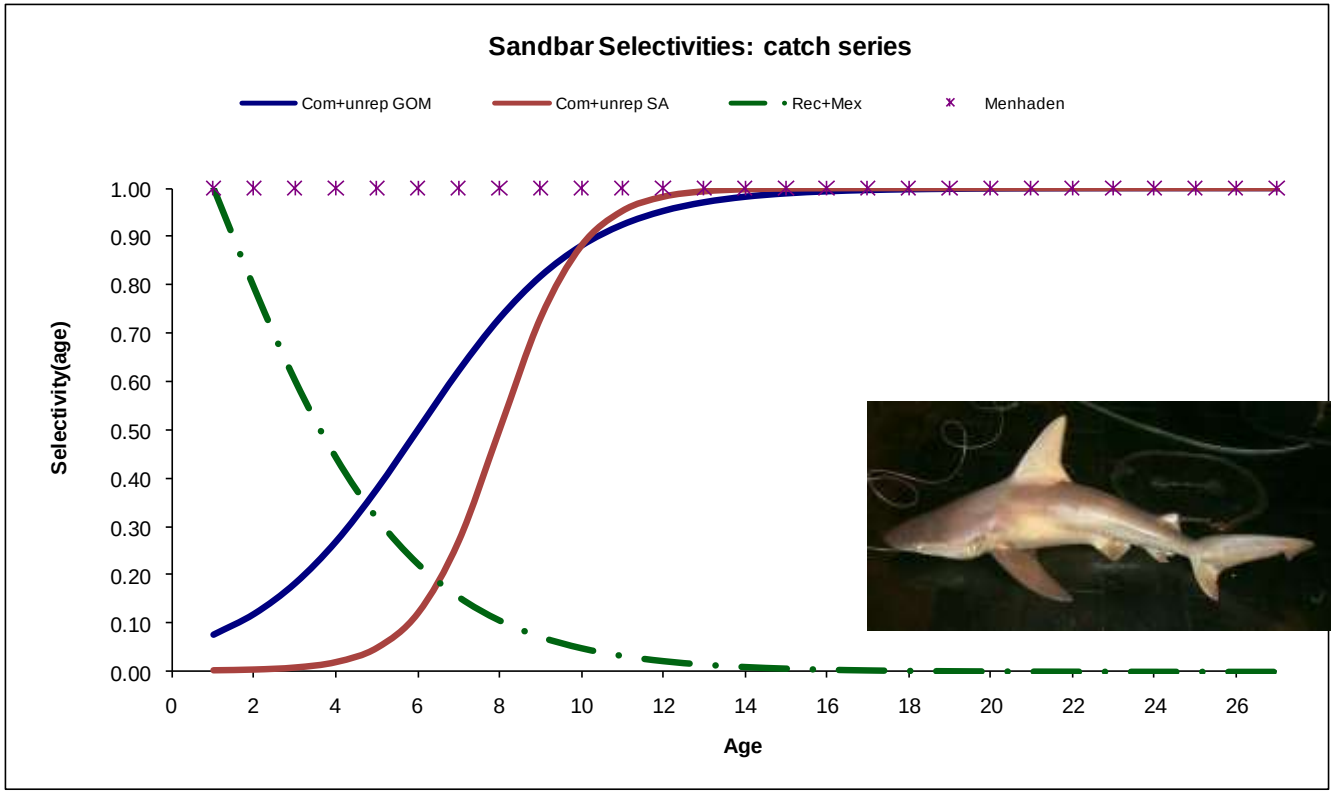






Selectivities

Example: Selectivities fitted to age composition of sandbar sharks that were obtained from lengths through an age-length key



Fishery-Dependent CPUE (standardized indices of abundance)

Most common ones are:

- Bottom longline observer program (directed shark fishery; 1994-)
- (Drift) gillnet observer program (1993-)
- Pelagic longline observer program (1992-)
- Large Pelagic Survey (LPS; recreational index for pelagic species; 1986-)

– Observer program-based indices generally preferred to corresponding indices derived from logbooks

– MRFSS and recreational indices generally not used because of species identification and other issues

– Generally good spatial coverage but subject to changes in regulations and fishing power (high potential for process error)

Fishery-Independent CPUE (standardized indices of abundance)

Most common ones are:

- Bottom longline shark survey (1995-)
- GOM shark pupping and nursery area gillnet surveys (GULFSPAN; several states; varying time coverage)
- SEAMAP SA coastal trawl survey (1989-)
- SEAMAP GOM groundfish trawl surveys (summer: 1982- ; fall: 1972-)
- Northeast longline shark survey (not annual; 1996-)
- VIMS bottom longline shark survey (1973-)
- UNC bottom longline shark survey (1973-)
- SEAMAP-GOM coastal inshore bottom longline shark survey (several states; varying time coverage)
- Other small-scale surveys and state-run or partner-run surveys

– Generally more limited spatial coverage and fewer observations than fishery-dependent indices, but less subject to changes in regulations and methodology

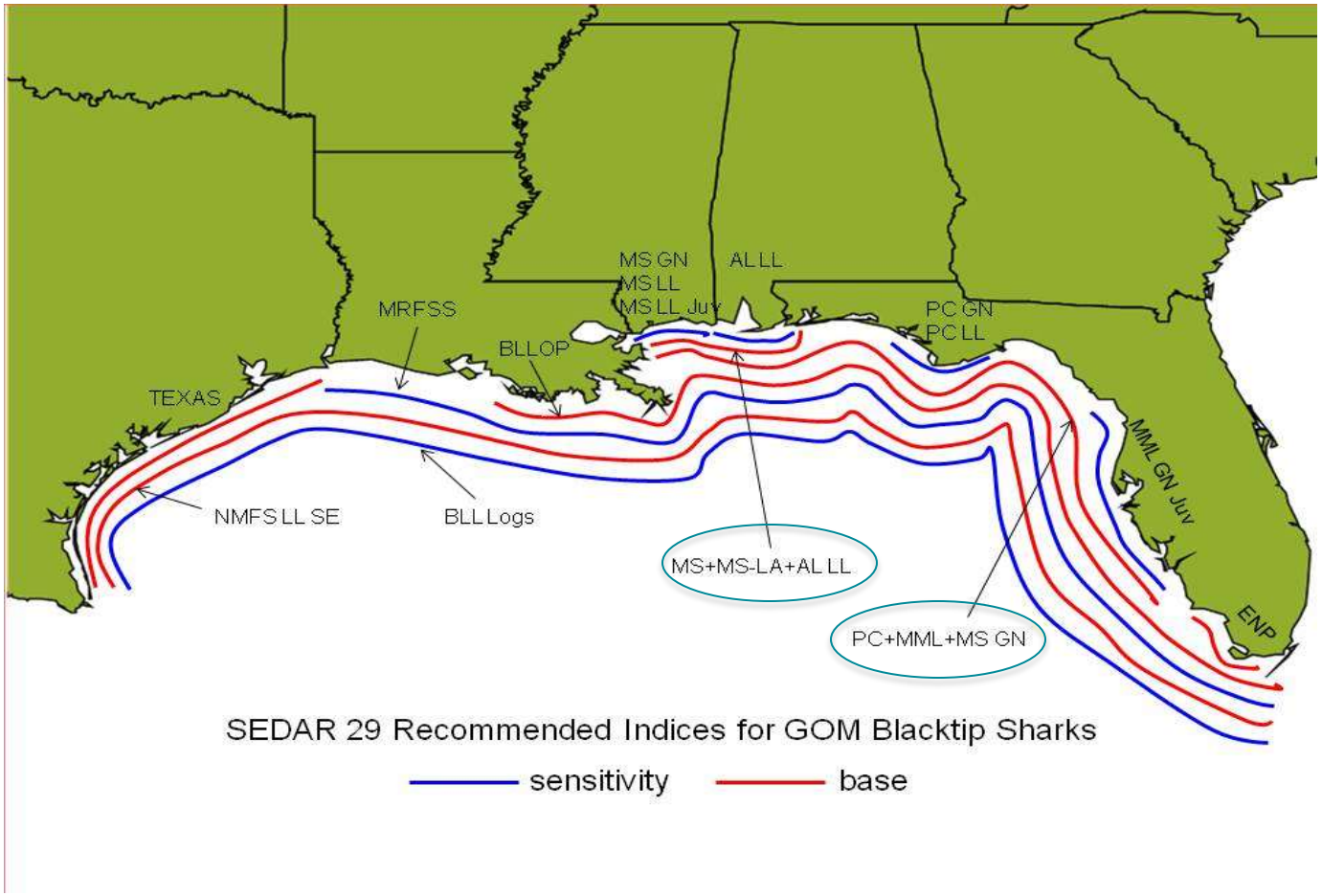
– Some with good temporal coverage (e.g., VIMS and UNC)

– Have recently started pooling small-scale indices with same methods and close geographic locations (e.g., Gulfspan, SEAMAP-GOM inshore longline surveys)

– Have also recently used single hierarchical index to account for process error

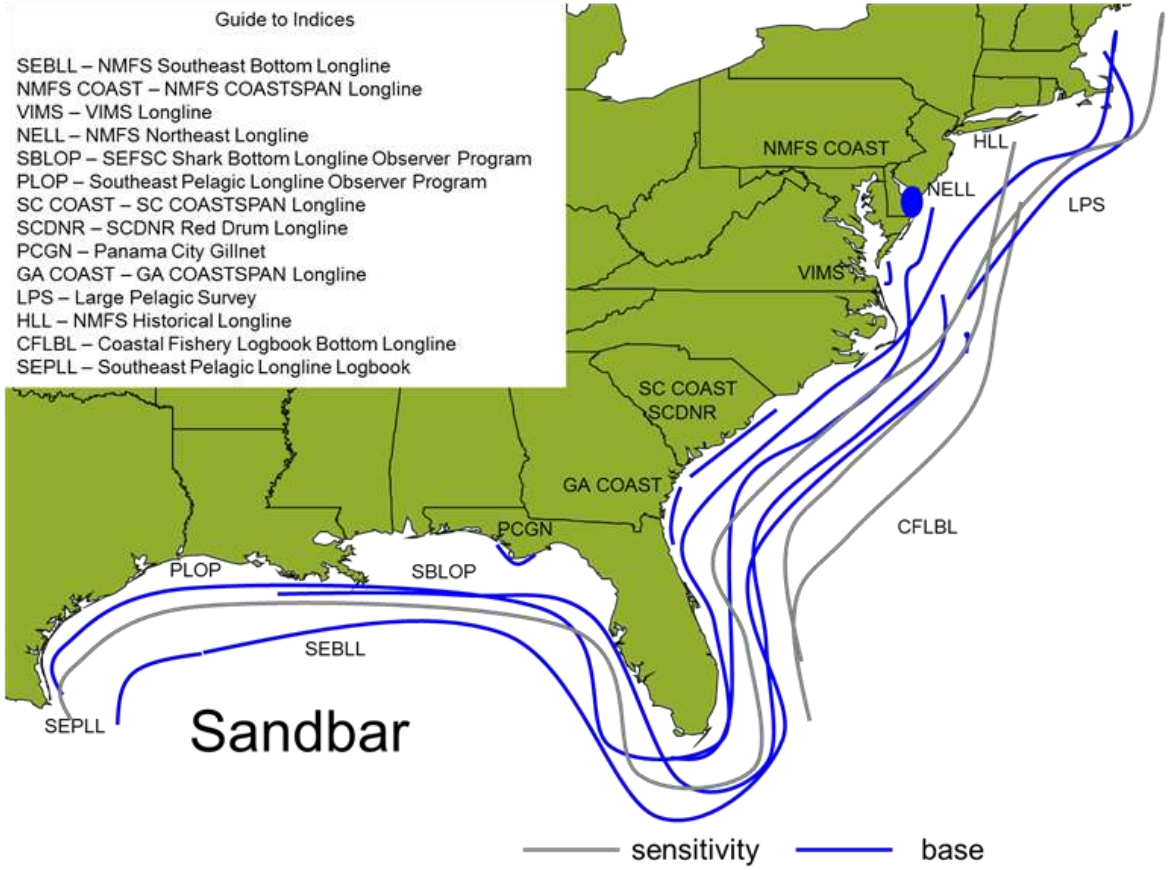
Combining multiple local indices

Example: Combining several F-I indices for GOM blacktip sharks



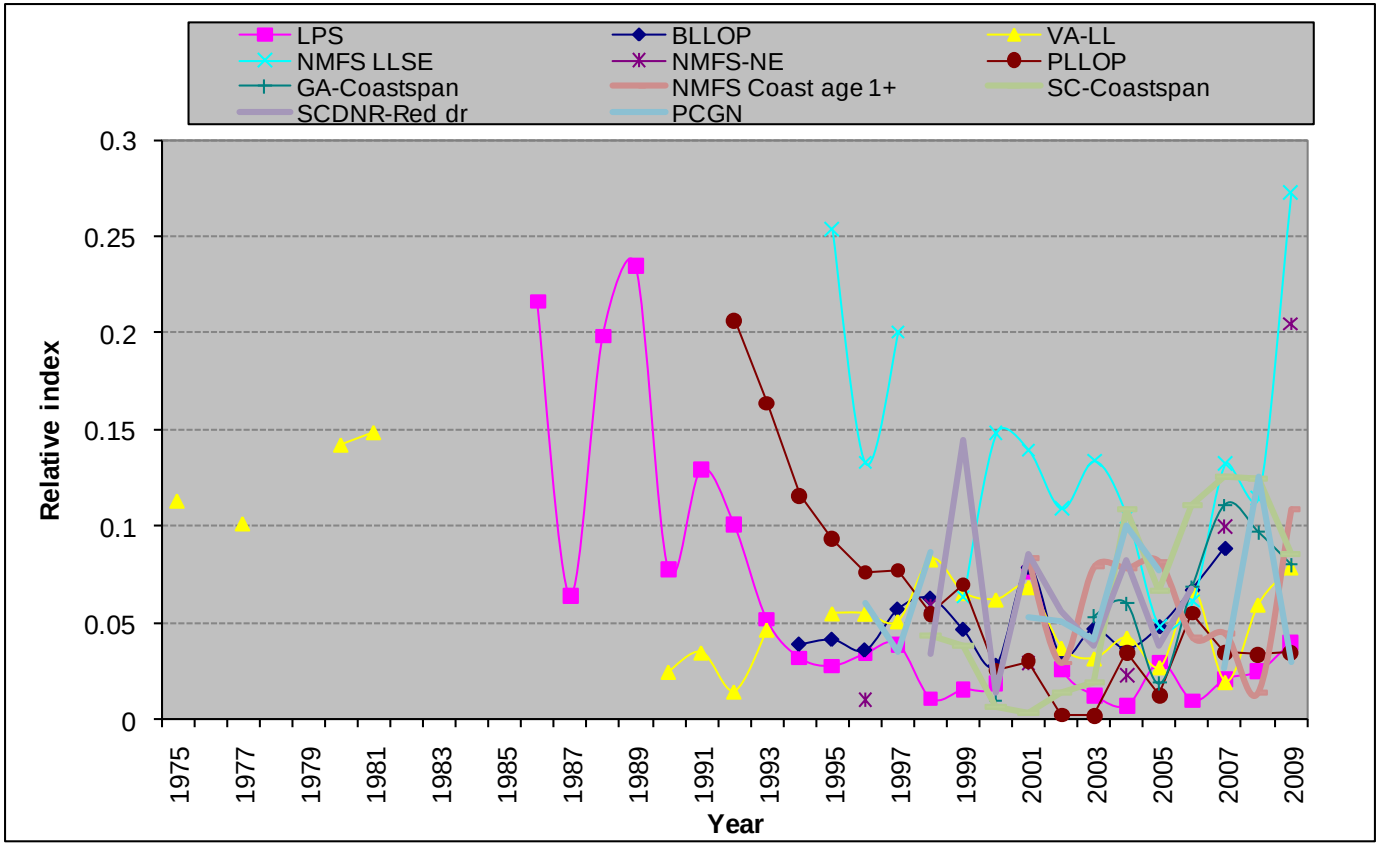
Indices

Example: F-D and F-I indices for sandbar sharks



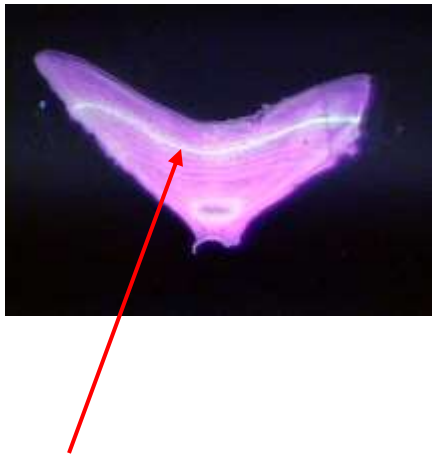
Indices

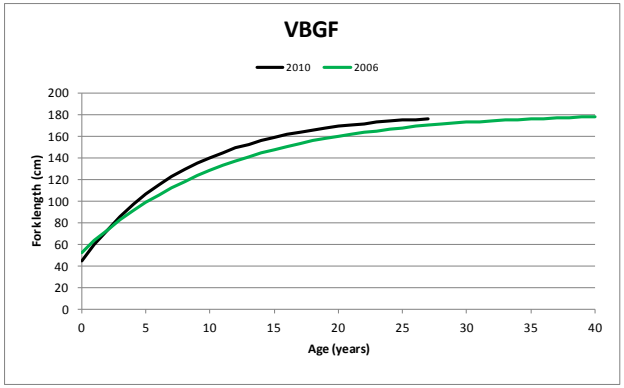
Example: Indices for sandbar sharks

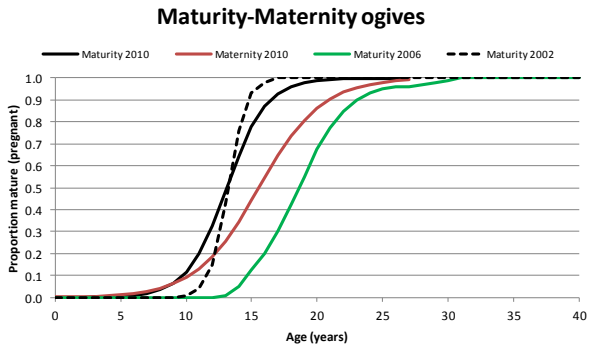


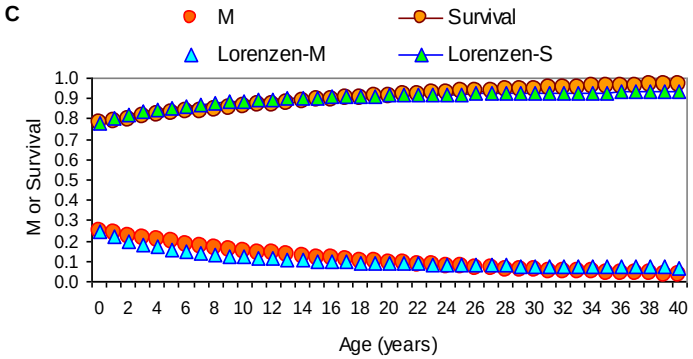
Life history information: issues

- Very few species with validated ages
- New studies typically result in different estimates of longevity and ages at maturity
- Length of reproductive cycle for several species unclear or variable
- Natural mortality estimated through “life history invariant” methods









Take home points

Catch (landings and discards) data

- Commercial landings well represented (near census) but only available form early 1990s
- Recreational catches are estimated and suffer from small sample sizes (lengths) and species identification problems in some cases
- Bycatch (discards) estimated, also suffer from small sample sizes due to limited observer coverage and historically low priority for sharks
- Sex recorded in observer programs and most fishery-independent surveys but not in most other fishery-dependent data collection programs

Take home points

CPUE (Indices of relative abundance)

- Logbook-based indices more precise, better spatial coverage, show lower interannual variation, but are less reliable than observer-based indices (lower sample sizes, higher interannual variation, but better species ID)
- Different indices often show conflicting trends
- The model assumes they track true relative abundance of the stock

Take home points

Biological Information

Age information:

- *No catch at age available*
- Limited length compositions available
- Limited age and growth studies
- Very few age validation studies

Reproductive information:

- Litter size generally well known
- Reproductive periodicity for several species is in question

Take home points

Stock, Spatial and other Information

- Stock structure information inexistent or in question for several species
- Tagging information limited
- Movement patterns still largely unknown for most species